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Diamonds and Water: A Paradox Revisited

On October 30, President Bush signed legislation into law that makes it possible for recipients of water from California's Central Valley Project to resell that water. This legislation is controversial, because it is expected to plant the seeds for the development of a water market in California. Among the most frequently cited objections to using markets to allocate water are concerns that the results would be unfair and disruptive. In particular, opponents argue that a move to market prices would mean a large shift in water from farms to cities. This change in water allocation, they argue, would lead to reduced agricultural income and production, lower income in agriculturally dependent communities, and higher food prices. In the extreme, this stylized scenario predicts a world with fountains in Beverly Hills and desolation in California's central valley farming region.

This vision of the distributional consequences of a market system for water results, in part, from putting together two statements about price determination and drawing the wrong conclusion. These statements are that (a) water is extremely valuable, and (b) that the value of a commodity is reflected in its price. Thus, the conclusion drawn by some is that water prices would be high in a market system and that low income and agricultural consumers would be severely limited in their abilities to purchase water.

This conclusion does not necessarily follow, however. In fact, a similar debate took place in the economics literature in the eighteenth and nineteenth centuries before being put to rest by Alfred Marshall. Known as the "Diamond-Water paradox," the issue sought to explain how the observed price of water could be below that of other commodities, such as diamonds, given water's high value in sustaining life. Marshall's solution to the paradox was to recognize that prices reflect the value of the last, or marginal, unit, not the value of all units consumed. He demonstrated that a commodity that has high value to society could have a low price if it were available in sufficient supply.

As discussed in this *Weekly Letter*, this insight is relevant to the current debate. The evidence suggests that water markets would not lead to a high price for water, because while urban users now pay a significantly higher price than agricultural users, that reflects differences in values of the last unit consumed by the two groups given artificial restrictions on trading. In fact, the evidence suggests that water use patterns would not be affected significantly, implying that the effects on agriculture and agricultural communities would not be large.

The paradox

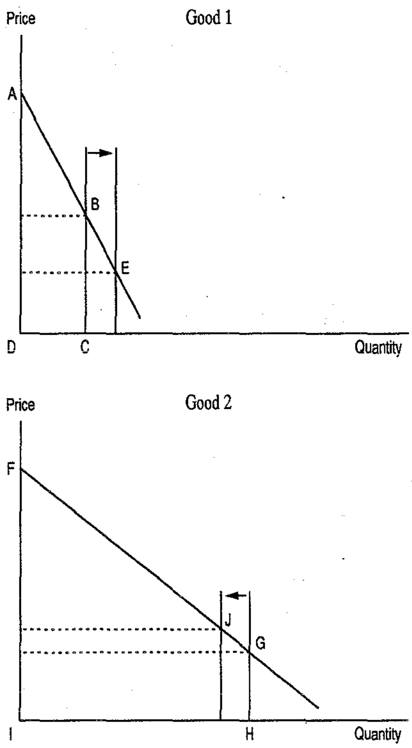
The diamond-water paradox was puzzled over for nearly a hundred years in the economics literature. Adam Smith considered the issue in the late eighteenth century, and David Ricardo spent considerable effort trying to understand this seemingly logical inconsistency with relative price determination. Why would water, which is essential to life, carry a price that is below that of diamonds, whose use is far less critical?

Ricardo, the father of the labor theory of value, tried to apply that theory to this case. He argued that the cost of a commodity reflected the embedded labor needed to bring that product to market. Thus, he argued that water was relatively cheap because it required less labor effort to acquire than did diamonds.

While seeming to solve the dilemma, it was left to Marshall to develop the correct answer to the paradox. Marshall's answer can be seen in the figure. Supply and demand curves for diamonds (good 1) and water (good 2) are shown in the two panels of the figure. As shown in the figure, prices are determined where supply and demand intersect in each market (points B and G), and given the low quantity of diamonds, the equilibrium price of diamonds exceeds that of water.

The important factor to note is that this is a marginal condition. Prices measure the value of the final unit consumed. The total value derived from use is measured by the area under the demand

Figure 1
Comparing Supply and Demand in Two Markets



curve up to the last unit, areas ABCD and FGHI, for diamonds and water, respectively. Clearly, even though the value of the last unit of diamonds is higher than that of the last unit of water, the *cumulative* value of water far exceeds that of diamonds.

The solution to the paradox, therefore, differentiates between marginal value (prices) and total value. It is not necessary for the price of water to be high to guarantee that it be used beneficially, nor does a low price necessarily reflect an inappropriately low total value for the resource. Instead, the price serves to ration water to users by applying the criterion that the value to those using water has to be at least as high as the price on the last unit, while those that do not receive water must value it at less than that price.

California water prices

Misunderstanding of this paradox underlies some of the fears about water markets expressed by agricultural and political groups. Concern is high in the agricultural regions that if farmers could sell their water, they would do so. The high prices currently paid by urban users for water are used as evidence that markets would allow those consumers to bid up the price paid by farmers to a high level. Given these prices, it is argued that selling water would be more profitable than growing crops, which would lead to a sharp curtailment of agriculture.

In fact, these fears are overstated. High water prices are observed in urban areas, but those prices are not indicative of a market price for a farmer's water. Urban prices are higher than agricultural prices for two basic reasons. First, urban prices are higher because the water has to be pumped further and treated to meet higher quality standards. In California, for example, these costs can exceed $100 per acre foot in many urban areas. Those charges would continue to be applied, which would result in a significantly higher urban price even with a market price at the wholesale level. Thus, a high urban price does not necessarily imply a high price for water at the farm level.

More importantly, current high urban prices reflect artificial limits on urban access to water. While those prices reflect urban users' willingness to pay given a fixed supply, their willingness to pay is likely to fall off sharply as more water is made available.

To see this point, return to the two figures. Let the figures reflect the supply and demand for water for two consumers, one urban (good 1), and one agricultural (good 2). Because water is not freely traded, the price for urban users is higher than that for agricultural users given the limited supply available to urban users. Consider a small transfer to urban users, however, as indicated by the shifting supply curves in each market. In that case, a small *increase* in the supply of urban water would cause a sharp drop in urban prices (from B to E), while causing a small increase in agricultural prices (from G to J). This asymmetric effect on the prices of the two user groups is the direct result of differences in the slopes of the demand curves of the different groups.

As with the Diamond-Water paradox, price differentials between agricultural users' willingness to pay and urban users' willingness to pay reflect differences in the marginal value of water given available supplies. If supplies were allowed to move between the two user groups, an equilibrium price (differing only by transportation and processing charges) would emerge that shifts a *minimal* quantity of water to urban users. Thus, the fact that urban users are currently willing to pay a higher price at the margin does not mean that they would pay that price for a large quantity of water offered by farmers.

Evidence

Some recent evidence is suggestive of the potential effect. Vaux and Howitt (1984) estimate that price effects on agriculture and the magnitude of water transferred in California would be relatively small under a market system. Using updated figures in 1991 dollars from that article, Schmidt and Cannon (1991) found that *average* agricultural water prices might increase as little as $2.60 per acre foot—from $54.61 to $57.23—while urban prices would fall significantly. The model also suggests that urban consumption would increase by less than a million acre feet per year. (Agriculture in California consumed approximately 28.5 of the total 34 million acre feet in 1985, which was the last "normal" year of water deliveries.)

These asymmetric effects on urban and agricultural prices reflect the features of the diagram. Urban prices are high because quantities are very limited. However, if supplies increase, the prices urban users are willing to pay would drop off sharply because their demands are very inelastic. In contrast, agricultural consumers' demands are more elastic at current levels of consumption. Consequently, agricultural users would be willing to sell some water even with relatively small increases in water prices. (Recent studies by agricultural economists suggest that a 10 percent increase in prices would free up 4 to 7 percent of agriculture's water which would translate to 20 to 40 percent more for nonagricultural users. Moreover, these estimates are for short run responses. Over the longer run, responses are likely to be much larger as farmers install new technologies that save water.)

The important implication from these studies is that the disruption caused by moving to a water market would be small. Most fundamentally, all users of water have downward sloping demand curves for water. Farmers derive greater value from the first unit of water they use than from the last unit, and while the last unit may carry a low value, the cumulative value of their water use is large. Thus, it is unreasonable to think that a slight increase in the market price of water would cause a farmer to stop all consumption—he would simply move back along his demand curve and use less.

Given the limited amount of additional water that would be consumed by nonagricultural sources if trading were allowed, price effects on the farms cannot be large, at least on average. Small cutbacks by individual farmers would be sufficient to generate enough water to clear the market with minimal agricultural price increases. Moreover, by engaging in those transactions, the farmer would have the financial resources to invest in water-saving technologies.

Conclusions

Opponents of water markets fear the disruptive effects of large increases in water prices that might emerge from water reform legislation such as that involving the Central Valley Project. However, studies estimating the magnitude of the potential price increase find only small increases, suggesting that the impact on water use will be minimal.

This deviation between evidence and perception recalls the struggle to resolve the "diamond-water paradox" posed over 200 years ago and its solution, which was a step forward in understanding price determination. Currently observed price differences between urban and agricultural markets reflect differences in the value of water at the margin to those users given artificial limitations on exchanges. If water is traded between the two parties, urban users quickly move down their demand curves, suggesting that their willingness to pay for the marginal unit—the price—will fall rapidly. Conversely, faced with a market decision, farmers would be encouraged to sell some—not all—of their water, which would cause agricultural prices to rise slightly, since they are at a comparatively flat portion of their demand curves. Because of these differences in the shapes of demand curves, small increases in agricultural water prices could free up enough water to make urban water prices fall considerably more—and have little real impact on the farm community.

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Index to Recent Issues of *FRBSF Weekly Letter*

DATE	NUMBER	TITLE	AUTHOR
5/15	92-20	Agricultural Production's Share of the Western Economy	Schmidt/Dean
5/22	92-21	Can Paradise Be Affordable?	Cromwell/Schmidt
5/29	92-22	The Silicon Valley Economy	Sherwood-Call
6/5	92-23	EMU and the ECB	Walsh
6/19	92-24	Perspective on California	Sherwood-Call
7/3	92-25	Commercial Aerospace: Risks and Prospects	Cromwell
7/17	92-26	Low Inflation and Central Bank Independence	Parry
7/24	92-27	First Quarter Results: Good News, Bad News	Trenholme/Neuberger
8/7	92-28	Are Big U.S. Banks Big Enough?	Furlong
8/21	92-29	What's Happening to Southern California?	Sherwood-Call
9/4	92-30	Money, Credit, and M2	Judd/Trehan
9/11	92-31	Pegging, Floating, and Price Stability: Lessons from Taiwan	Moreno
9/18	92-32	Budget Rules and Monetary Union in Europe	Glick/Hutchison
9/25	92-33	The Slow Recovery	Throop
10/2	92-34	Ejido Reform and the NAFTA	Schmidt/Gruben
10/9	92-35	The Dollar: Short-Run Volatility and Long-Run Adjustment	Throop
10/16	92-36	The European Currency Crisis	Glick/Hutchison
10/23	92-37	Southern California Banking Blues	Zimmerman
10/30	92-38	Would a New Monetary Aggregate Improve Policy?	Motley
11/6	92-39	Interest Rate Risk and Bank Capital Standards	Neuberger
11/13	92-40	NAFTA and U.S. Banking	Laderman/Moreno
11/20	92-41	A Note of Caution on Early Bank Closure	Levonian
11/27	92-42	Where's the Recovery?	Cromwell/Trenholme

The *FRBSF Weekly Letter* appears on an abbreviated schedule in June, July, August, and December.